Large-scale balancing and energy storage from Norwegian hydropower – Potential and challenges

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Energy balancing using hydropower

- Hydro storage vs. pumped storage

- Storage across entire time scale
- Efficiency up to 80% round-trip
- Most economic means of storing energy on large scale
- Various types of ancillary services
Hydropower in Norway

- Large number of reservoirs
- Storage capacity

> 100 pairs of large reservoirs
20 reservoirs > 100 Mm³ both up- and downstream
about 85 TWh storage
Blåsjø
7.8 TWh Reservoir
(1000 times Goldisthal)
Hydropower in Norway

- Hydropower and wind power are complementary

Monthly average wind power generation and inflow to hydropower
Simulated wind power production in the North Sea area in 2030
95 000 MW installed capacity
Wind power North Sea area – July-September 2001
Wind Power North Sea area – January-March 2001

One week balancing means
Ca 30 000 MW in 168h ➞ 5 000 GWh energy storage

Same as 1000 typical PSH

Can hydropower in Norway supply this storage?
Potential in Norway

Increasing balance power capacity in Norwegian hydroelectric power stations – A preliminary study of specific cases in Southern Norway
Solvang et al. (2011)

- New power stations
- Hydro storage + pumped storage
- Existing reservoirs and dams
- Outlet into reservoir or fjord/sea
- 20.000 MW possible by 2030
HydroBalance Project – Environmental, technical, economic and social challenges
Oct 2013 - Oct 2017

• Scenarios for different futures of the Norwegian hydro system in 2050
• Roadmap
• Analyses, simulations and case studies of
  – energy system
  – energy market
  – environmental impacts
  – regulatory framework and public acceptance
Scenario building

Formulation of the key research question

Which role can energy balancing and storage by Norwegian hydropower play in the European electricity market in 2050?

Identification of most important, uncertain factors (Uncertainties)

Identification of most important controllable aspects (Options)

Definition of Futures as combinations of Uncertainties

Definition of Strategies as combinations of Options

Scenarios
HydroBalance scenarios

Among most important uncertainties:
1. Share of variable renewable energies
2. Competition from other alternative flexible technologies

![Diagram showing the HydroBalance scenarios with axes for low and high share of variable RES in Europe and low and high competition from alternative flexible technologies.](#)
Conclusions

• Importance of time horizon
  – different types of services
  – different technologies
  – different power markets

• Potential of Norwegian hydropower

• Challenges to solve
  – Economic viability
  – Environmental impacts
  – Public acceptance
Thank you for your attention

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